PROCEEDINGS.

Seven hundred and sixty-third Meeting.

May 29, 1883. — ANNUAL MEETING.

The PRESIDENT in the chair.

The Treasurer and the Librarian presented their annual reports.

The Corresponding Secretary read the annual report of the Council.

The chairman of the Rumford Committee presented the following

REPORT OF THE RUMFORD COMMITTEE FOR THE YEAR.

Since the last report various scientific investigations have been instituted by the Committee as follows: —

I. Experiments in photographing the solar spectrum with the improved dry plates; conducted under the direction of Professor Pickering, by Mr. W. H. Pickering. The Committee have expended on this account $233.56, viz.: —

Scott's bills, $7.75 and $15	$22.75
French's bill	69.80
Clark & Sons' bill	85.00
Stevens, for labor, &c.	56.01
	$333.56

II. Experiments on the so-called Thomson effect in Thermo-electricity, and related subjects; conducted by Professor Trowbridge. The Committee have expended on this account $323, viz.: —

To Williams, for large Bunsen battery . . .	$225.00
" " for large adjusting coils . . .	98.50
	$323.50

The Committee have had under consideration, for two years, scientific work of great merit by various individuals with reference to an appropriate selection of a candidate for the Rumford Premium; and, after much deliberation, have come to a unanimous agreement to recommend to the Academy the adoption of the following votes: —

Voted, That the Rumford Premium be awarded to Professor H. A. Rowland, of Baltimore, "For his researches in Light and Heat."

Voted, That the Rumford Committee be authorized to draw upon the Treasurer of the Academy for the expenses incurred in the preparation of the gold and silver medals which constitute the Rumford Premium, and charge the same against the income of the Rumford Fund.

All of which is respectfully submitted.

JOSEPH LOVERING,
Chairman of Rumford Committee.

The report was accepted and the votes recommended were adopted.

On the motion of the Corresponding Secretary, it was

Voted, That the following should be substituted in place of No. 4 of the standing votes of the Academy: —

"One hundred extra copies of each paper published in the Memoirs or Proceedings of the Academy may be separately printed for immediate distribution, and placed at the disposal of the author free of charge; and, at the special request of the author, this number may be increased to two hundred."

The following gentlemen were elected members of the Academy: —

George Basil Dixwell, of Boston, to be a Resident Fellow in Class III., Section 3.

John William Mallet, of Charlottesville, Virginia, to be an Associate Fellow in Class I., Section 3.

Atticus Greene Haygood, of Oxford, Georgia, to be an Associate Fellow in Class III., Section 1.

Charles Adolphe Wurtz, of Paris, to be a Foreign Honorary Member in Class I. Section 3, in place of the late Friedrich Wöhler.

The annual election resulted in the choice of the following officers: —

JOSEPH LOVERING, *President.*
OLIVER W. HOLMES, *Vice-President.*
JOSIAH P. COOKE, *Corresponding Secretary.*
JOHN TROWBRIDGE, *Recording Secretary.*
HENRY P. KIDDER, *Treasurer.*
SAMUEL H. SCUDDER, *Librarian.*

Council.

EDWARD C. PICKERING,
AMOS E. DOLBEAR,
ROBERT H. RICHARDS, } of Class I.

HENRY P. BOWDITCH,
ASA GRAY,
ALEXANDER AGASSIZ, } of Class II.

EDWARD ATKINSON,
JAMES B. AMES,
JUSTIN WINSOR, } of Class III.

Rumford Committee.

WOLCOTT GIBBS, JOHN TROWBRIDGE,
EDWARD C. PICKERING, JOSIAH P. COOKE,
JOHN M. ORDWAY, JOSEPH LOVERING,
GEORGE B. CLARK.

Member of Committee of Finance.

THOMAS T. BOUVÉ.

The President appointed the following standing committees: —

Committee of Publication.

ALEXANDER AGASSIZ, JOSIAH P. COOKE,
AMOS E. DOLBEAR.

Committee on the Library.

HENRY P. BOWDITCH, WILLIAM R. NICHOLS,
HENRY W. HAYNES.

Auditing Committee.

HENRY G. DENNY, ROBERT W. HOOPER.

The following papers were presented: —

"Recent Volcanic Phenomena on the Hawaiian Islands." By William T. Brigham.

"The Flow of Lava Streams as illustrated by the Hawaiian Eruption of 1881." By William T. Brigham.

The following papers were presented by title: —

Contributions from the Chemical Laboratory of Harvard College: —

1. "On Turmerol." By C. Loring Jackson and A. E. Menke.

2. "On Curcumin." By C. Loring Jackson and A. E. Menke.

3. "On the Action of Phosphorous Trichloride on Aniline." By C. Loring Jackson and A. E. Menke.

4. "On the Action of Sodic Ethylate on Benzaldehyde." By C. Loring Jackson and G. T. Hartshorn.

5. "On the Action of Concentrated Hydrobromic Acid upon Mucobromic Acid and other Related Substances." By Henry B. Hill.

6. "On the Action of Alkaline Hydrates upon Mucobromic Acid." By Henry B. Hill and E. K. Sterns.

7. "On Phenoxychloracrylic Acid." By M. Loeb.

8. "On the Determination of Nitrites with Potassic Permanganate." By L. P. Kinnicutt and J. U. Nef.

9. "On the Determination of Sulphites with Potassic Permanganate." By L. P. Kinnicutt and R. Penrose.

"Weber's Theory of Magnetism." By John Trowbridge and C. B. Penrose.

On the motion of the Corresponding Secretary, it was

Voted, To adjourn this meeting to the second Wednesday in June.

Seven hundred and sixty-fourth Meeting.

June 13, 1883. — ADJOURNED ANNUAL MEETING.

The PRESIDENT in the chair.

The President announced the death of Gabriel Gustav Valentin, Foreign Honorary Member.

On the motion of Mr. Winsor, it was

Voted, To appropriate for the coming year, subject to the approval of a future stated meeting: —

For general expenses	$2,200.00
For publishing	2,000.00
For library	1,250.00

The following papers were presented: —

"A Method of Correcting the Weight of Bodies for the Buoyancy of the Atmosphere." By Josiah P. Cooke.

"Connection between Vision and the Kinetic Theory of Gases." By Amos E. Dolbear.

"Conversion of Camphor into Borneol." By C. Loring Jackson and A. E. Menke. (By title.)

Seven hundred and sixty-fifth Meeting.

October 10, 1883. — STATED MEETING.

The PRESIDENT in the chair.

The President announced the death of Sir Edward Sabine, of Woolwich, Foreign Honorary Member; and of Stephen Alexander, of Princeton, N. J., and William A. Norton, of New Haven, Associate Fellows.

The appropriations recommended at the adjourned annual meeting were confirmed.

The following gentlemen were elected members of the Academy: —

Arthur Michael, of Medford, to be a Resident Fellow in Class I., Section 3.

Ira Remsen, of Baltimore, to be an Associate Fellow in Class I., Section 3.

Charles Hermite, of Paris, to be a Foreign Honorary Member in Class I., Section 1, in place of the late Joseph Liouville.

The following papers were presented: —

"On Standard Time." By J. Rayner Edmands.

"On the Latitude of Harvard College Observatory, from Observations in the Prime Vertical in 1865." By William A. Rogers.

"On the Zodiacal Light." By Arthur Searle.

"The Fossil White Ants of Colorado." By Samuel H. Scudder. (By title.)

On the motion of Professor Pickering, it was

Voted, To appoint a committee, with power to consider the introduction of the system of standard time now under deliberation by the managers of railroads in the United States and Canada.

The chair appointed the following members upon this Committee: —

Messrs. Wolcott Gibbs, Francis A. Walker, and J. Rayner Edmands.

Seven hundred and sixty-sixth Meeting.

November 14, 1883. — MONTHLY MEETING.

A quorum was not present, and the Academy was not called to order.

Seven hundred and sixty-seventh Meeting.

December 12, 1883. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President announced the death of John Lawrence Smith, of Louisville, and John Lawrence Le Conte, of Philadelphia, Associate Fellows; and of Oswald Heer, of Zurich, Foreign Honorary Member.

The following paper was presented: —

"On Vortex Rings studied experimentally." By Amos E. Dolbear.

Seven hundred and sixty-eighth Meeting.

January 9, 1884. — STATED MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters announcing the death of Joachim Barrande, of Prague, and Oswald Heer, of Zurich, Foreign Honorary Members; also a letter from Charles Hermite, acknowledging his election as Foreign Honorary Member.

The death was announced of Andrew A Humphreys, of Washington, Associate Fellow; and of Evangelinus A. Sophocles, of Cambridge, and Calvin Ellis, of Boston, Resident Fellows.

Mr. Edmands presented the following report of the committee on Standard Time.

TO THE PRESIDENT OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES: —

SIR, — The Committee appointed to consider the advisability, with reference to the public convenience, of an acceptance by cities and towns of the system recently adopted by the railroads of the United States and Canada, by which the time will be uniform within each of five sections of North America, respectfully recommend the general introduction of the system for the following reasons.

It is of the greatest practical importance in a business community and among travellers to have an accepted standard time, to which well-constructed clocks and watches conform. True solar time is not regular enough for this purpose, since clocks cannot be made to keep time with it. "Mean time" is an arbitrary device which overcomes the difficulty. At different seasons of the year it is alternately faster and slower than true solar time; yet it serves practical purposes so well, that many persons are ignorant of the fact that the difference exists. As the division of the day into twenty-four hours and the calling of noon "twelve o'clock" are both mere conventional arrangements, no difficulty has been found in calling it twelve o'clock when an imaginary or "mean" sun crosses the meridian, although twice a year this mean noon varies more than a quarter of an hour from true solar noon.

For places in different longitudes, mean noon occurs at different instants. Many a suburban resident would find his watch a minute

wrong by city time should he keep it true to the local time of the town where he lives. But he fails to notice this fact because none of the clocks in his town show the local time. Suburban clocks are made to agree with those of the city, and the city clocks often show the time of some larger city. For example, there is hardly an inland city in New England which uses its own local time. Clock time, therefore, is arbitrary and conventional in nearly every respect. It is an invention which has been modified from time to time to suit practical convenience. Even in legal matters no one would think of appealing to the *true* solar time, but in the absence of statute would rely upon whatever standard is used by common consent.

The greater importance of precise time to us than to our ancestors is due to our increased facilities for dealing with those who live at a distance, — to the railroad, the telegraph, the telephone, and the fast mail. The same causes make it the more necessary to be punctual in appointments with neighbors. It is difficnlt to realize how much more important an exact knowledge of the time is for purposes of this sort than for all others. Few persons really appreciate the number and variety of interests which depend in one way or another upon the arrival and departure of trains. This is especially true of a city surrounded by well-developed suburbs. A large amount of the business of Boston, for example, is done by people who enter and leave the city daily by railroad, and the nnmber of these increases every year.

The consideration which induces a community to allow its time to differ from the local time, is the existence of a railroad which uses the time proper to some other longitude. There are no instants marked out by nature as the times for men to perform their daily recurring acts. Hours for meals vary widely; and people show the latitude which exists in the choice of times for beginning work or amusements, by taking even hours and half-hours in preference to the intermediate quarters or smaller divisions. Whatever be the standard of time, men's daily affairs can be appointed according to convenience; and, if it be desired to use even hours and half-hours by the clock, the railway standard offers as many chances for convenient arrangements as does local time. The best plan is, then, for all the time-pieces, public and private, to conform to that standard. As each railroad carries one standard to two termini, this plan is inconsistent with the general use of local time.

Heretofore there have been over fifty different standards in use at once upon the railroads of the United States and Canada. In many

places, moreover, where two or more standards are used, the local time enters to increase the confusion. Remedies for this state of things have been studied by able scientific men, discussed at length by learned societies, and developed practically by railroad managers. All purely ideal solutions have had to give way to those considerations which affect the *convenience of the public.* For example, an early suggestion was for the railroads to use one universal standard, while each community should use its own local time. But such a scheme is visionary, since neither the railroads nor the people would put it into practice. According to the plan which the railroads have recently adopted, the minute-hands of watches all over the country are to be in coincidence, but the hours are nowhere to depart far from local time; and thus the troublesome necessity of allowing for a difference of an odd number of minutes is avoided. Again, the boundaries between sections using successive hours are to be fixed with due regard to economic considerations.

Those American communities which have heretofore had their own local times must now consider whether to retain them, or submit to the temporary inconvenience of adopting the new standard, which is to come into use by the railroads. The recurring seasons of the year and the gradually altering conditions of a city often call for altering the time set to start a train, begin work, or open a public entertainment. Some inconvenience immediately results, but it is quickly compensated. If the standard of time be changed, many appointments will remain the same by the clock, with positive improvement in some cases, while others will be soon shifted according to convenience. Men will not continue long to do things too late or too early in the day just because the standard has been altered. Suppose, for example, that the clocks of a city are put back a quarter of an hour. If the time set for opening a school or factory had heretofore been thought rather early in the day, the change would be beneficial. If, on the other hand, the hour for opening had been thought rather late, the selection of a half-hour earlier by the clock would effect the same improvement. In a few weeks after the introduction of the new standard, people will be amazed to see how little is the difference it has made in matters about which anxiety is now expressed.

The introduction of uniform time will be no new experiment. In the year 1848, England, Scotland, and Wales adopted Greenwich time as a standard for the railways, the change for the western part of Scotland exceeding twenty minutes. This railway standard is now used for all ordinary purposes throughout the island. The evils which

some people feared would accompany or follow its introduction never came, and the experience of a generation with uniform time has not developed any desire to return to the system of local time.

The American case only differs from the British in the breadth of our country, which requires to be divided into several sections, whose standards differ by whole hours. Each section, however, is comparable with Great Britain. It is true that a city located upon a boundary between sections does not reap the full advantage possessed by more centrally located places, but the new system will be better than the old, even on the frontiers of the sections.

Let us trace the effect of the adoption of the new standard by the railroads upon any city which has heretofore been able to impose its local time upon the surrounding country, taking Boston as an illustration. Evidently the very causes which brought the time of the neighboring places into coincidence with that of the larger city will now carry the time of those places over to the new standard, which in this case is nearly that of Philadelphia. That is, Taunton and New Bedford, Worcester and Springfield, Fitchburg and North Adams, Lowell and Concord, Lawrence and Dover, and Portsmouth and Augusta, have heretofore used Boston time solely because their railroads did so; but when the railroads give up Boston time the bond will be broken, and Boston can only preserve the uniformity by conforming to the new standard.

Such considerations lead us to the conclusion that any city, however large, which maintains its local time after the railroads have deserted it in favor of the new standard, will isolate itself from the time of the country, and bring constantly recurring annoyance upon its citizens, its visitors, and those who deal with it by telegraph.

In order to avoid perplexities for the first few days under the new system, it is important that people throughout the country should realize that we have now the consummation of a scheme deliberately considered in all its details, and brought about by means which insure its permanence. The movement is irresistible. Officials and local boards, with which the authority may lie, should therefore take formal action in favor of it. Mills, banks, brokers' boards, and schools should announce their intention to conform to it. Lawyers and insurance companies should prepare themselves to use the slight verbal precautions which will prevent litigation arising from any uncertainty during the first few days following the change. And individuals generally should adapt their plans to the new arrangements. Already the railroads are prepared. But inaction on the part of communities leaves

room for possible misunderstandings and legal difficulties, which would be averted by a little foresight and promptness of action.

(Signed,) WOLCOTT GIBBS, FRANCIS A. WALKER, J. RAYNER EDMANDS, } *Committee.*

Professor Henry P. Bowditch called the attention of the Academy to the necessity of better library accommodations; and, on his motion, it was

Voted, That a committee be appointed to consider this subject.

The chair appointed the following committee: —

Messrs. Henry P. Bowditch, Josiah P. Cooke, and Henry P. Kidder.

The following gentlemen were elected members of the Academy: —

Oliver Clinton Wendell, of Cambridge, to be a Resident Fellow in Class I., Section 2.

Joseph Thatcher Clarke, of Boston, to be a Resident Fellow in Class III., Section 2.

The following papers were presented: —

"Additional Observations confirmatory of the Relation: Imperial yard + 3.37027 inches = Metre des Archives." By William A. Rogers.

"A Possible Explanation of the Discordant Values of the Equinox determined by Pond between 1820 and 1833." By William A. Rogers.

"Observations on Variable Stars by Sir William Herschel." By Edward C. Pickering. (By title.)

Seven hundred and sixty-ninth Meeting.

February 14, 1884. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read a letter from the University of Edinburgh, inviting the Academy to send a delegate to its Tercentenary Celebration during Easter week.

The selection of a representative was left to the officers of the Academy.

The death of Arnold Guyot, of Princeton, N. J., Associate Fellow, was announced.

The special business assigned for this meeting was the presentation of the Rumford medals, which had been awarded at the annual meeting, in accordance with the recommendation of the Rumford Committee.

The President made the following address in presenting the medals to Professor Rowland: —

The medals awarded to Professor Rowland have been struck at the Philadelphia Mint, and appropriately engraved under the direction of the Rumford Committee. Their delivery to the recipient has been postponed for several meetings, under the hope and expectation that Professor Rowland would find it convenient to be present, and receive the medals in person. His attendance with us now is warmly welcomed, and adds greatly to the interest of the occasion. I ask your kind attention to a brief statement of so much of the scientific work of Professor Rowland as justifies the award of the Rumford premium, and of the relation in which these researches stand to the present condition and needs of physical science.

Astronomy, at least that part of it which relates to celestial mechanics, has presented for many generations unchallenged claims to a precision not attainable in any other science. The comparative simplicity of its problems, involving only the familiar and measurable units of mass, space, and time, has enabled it to attain and to hold this distinguished position, in spite of the fact that all the senses except vision are excluded from its study. If it has received any assistance from the experimental laws of mechanics, much more have these laws been illuminated by the motion of the planets, where friction and other resistances do not interfere.

After Grove, in 1842–43, had published his lectures on the correlation of the various physical forces; after Mayer, Helmholtz, and others had published their conclusions (the deductions partly of theory and partly of experiment) that these different forces were mutually convertible; and after the view first seized in prophetic vision by Bacon, Locke, and Winthrop was experimentally established by Rumford, Davy, Joule, and numerous coadjutors, and with ever-increasing clearness, that the assumed caloric was imaginary, and that heat was only one kind of motion in ordinary matter, —

then it was possible to introduce unity, harmony, and precision into all the physical sciences by making the familiar units of measurement universal. As other forms of energy (mechanical, electrical, magnetic, chemical, capillary, radiant, and gravitation) can be converted, directly or indirectly, into heat-energy, heat has become a universal standard of energy, current everywhere in science, and redeemable. Hence it has become of prime importance to determine the mechanical equivalent of heat, — the amount of heat, for example, which corresponds in energy to a given mass falling through a given height in a given latitude. In this way heat and all its dependencies will be measured by the units of ordinary work. For more than forty years, physicists in different countries, and by various methods, led by Joule, have been engrossed with this measurement, reaching results which have slowly but happily converged towards a common agreement.

Professor Rowland, after an historical and critical review of the methods and results of older cultivators in this rich field, has turned up the soil anew, deepening the furrows.

The fruits of his long and patient labor were made known to the Academy in 1879, in Volume XV. of the Proceedings. New apparatus was devised; the comparative merits of mercurial and air thermometers were discussed; and the various constants of science which enter into the case were re-examined. The research is a model of ingenious and conscientious experimentation, and was not published until it had received from its author the same severe criticism which he had applied to the work of others. That his final conclusion harmonizes so well with the best of Joule's, increases our confidence in both. A larger discrepancy might have given a greater show of originality; but science would have paid for the novelty by a loss of security, and another revision of the whole subject would have been entailed upon it.

When Newton announced his dynamical theory of the solar system, as simple as it was comprehensive, it made slow headway against the fanciful hypothesis of Descartes, which was intrenched in all the universities of Europe. And yet Newton's theory reposed upon a firm mathematical foundation; while that of Descartes submitted to no quantitative tests, and contradicted all the known laws of mechanics. The history of astronomy from that time almost to the present moment tells of ever new victories achieved by the combined attacks of the telescope and mathematical analysis in the province of celestial mechanics, presenting the law of gravitation as supreme

dictator to planetary and sidereal systems. But these triumphs, complete in their details, and grand in their cosmical range, were limited to questions which concern the distances, motions, dimensions, and masses of the heavenly bodies. The law of gravitation can assign a value to the quantity of matter in planets and binary stars; but it asks and can answer no question in regard to the quality of this matter, only so far as a comparison of the size and mass of a body gives a measure of its density. That an instrument would be invented or developed which would complement the mechanics of the heavens by the chemistry of planets, comets, and stars, so that a physical observatory would become a necessary adjunct of the old observatory, was beyond the hope of the most sanguine astronomer, down to the moment of its actual realization.

Newton owes his singular fame, not exclusively to his discovery and expansion of the law of gravitation, bnt partly to his experimental researches in optics. That he did not recognize the dark lines in the solar spectrum has been explained by the statement that he was obliged to use the eye of an assistant in these experiments, on account of an injury to his own. Be this as it may, the existence of these lines was first known to Wollaston in 1802; and from that moment the spectroscope and spectrum-analysis, as we now understand them, were possibilities.

Although Fraunhofer made a careful study of these lines in 1824, and Brewster, Herschel, Talbot, Draper, and many others, pursued the inquiry by way of experiment and explanation, and stood upon the threshold of a great discovery, the spectroscope and spectrum-analysis, as practical realities, date from the investigations of Kirchhoff and Bunsen, in 1862. Not only does the spectroscope carry chemistry into regions tenanted only by planets, comets, stars, and nebulæ, and reveal motions in the direction of the line of vision otherwise hopelessly beyond recognition, but it competes with the ordinary chemical analysis of bodies which can be handled, and has detected new substances which had escaped the vigilance of the chemist. Some of these results can be realized with simple instruments: others require a compound spectroscope consisting of a battery of prisms. It was a great step in the way of simplicity and ease of manipulation, when the diffraction-spectrum, produced by fine lines ruled upon glass or metal, was substituted for the spectrum produced by the combined refractions of many prisms. And here we touch upon the researches of Professor Rowland in light, which enhance his claim to the Rumford premium.

Professor Rowland's improvements in the diffraction-spectrum are manifold. 1. He has substituted for the flat plate on which the grating was formerly ruled a spherical or cylindrical surface. 2. He has ruled these lines to such a degree of fineness that 5,000, or 42,000, or even 160,000, have covered only one inch. 3. This exquisite work was executed by a machine of his own invention, and produced spectra free from the so-called ghosts which result from periodical inequalities in the ruling. 4. By making the curvature of the ruled plate discharge the office of a lens, he has avoided absorption at the violet end of the spectrum. 5. By his simple mechanical arrangements, different parts of the spectrum can be photographed with a great economy of time, and with such excellence of definition that old lines are subdivided, and new ones spring into visibility. 6. The spectrum obtained is the normal spectrum. In the words of a competent authority on the subject, "the gratings of Mr. Rowland make a new departure in spectrum-analysis." 7. Finally, his mathematical exposition of the theory of gratings has explained observed anomalies, indicated the conditions of success, and prophesied the limits at which future improvements in spectrum-analysis must stop.

Professor Rowland, it is now my duty, and certainly it is a most agreeable one, to present to you, in the name of the Academy, the gold and silver medals which constitute the Rumford premium. Count Rumford, in conveying this trust to the Academy through President John Adams, expressed a preference for such discoveries as should, in the opinion of the Academy, tend most to promote the good of mankind. The practical applications of science are numerous and valuable, and are sure of popular recognition and reward; but they often come from the most unexpected quarters. No one can predict what wonderful points of contact may be suddenly revealed between a purely theoretical investigation and the practical utilities of life. Meanwhile, a deeper insight into the laws of the material universe, extorted from a reluctant Nature only after long and patient labor and thought, and many disappointments, becomes a permanent possession for mankind; and, as long as man does not live by bread alone, it is for him a perennial blessing. The Academy, in awarding the Rumford premium to you, has indicated the kind of scientific work which, in its opinion, tends most to promote the *highest* good of mankind.

I ask you to accept, with these medals, my warm congratulations, and the cordial good wishes of all the members of the Academy here assembled to administer Count Rumford's trust.

On receiving the medals, Professor Rowland spoke as follows: —

MR. PRESIDENT, AND GENTLEMEN OF THE ACADEMY: —

I thank you for the honor you have conferred upon me, which I can but regard as the greatest honor of my life. In receiving these medals, I am pleased to think that they have been conferred upon work which is not the result of a happy accident, but of long and persistent endeavor.

There are some investigators whose disposition permits them to follow their aim, inspired by the mere love of the labor and the work. There are others to whom the sunshine of appreciation is necessary. To either class, appreciation, when it comes, is always acceptable; and I assure you that the judgment set upon my investigations by this Academy is highly valued by me.

It has been intimated that a short account of my work would be of interest to the members of the Academy. My attention was first called to the construction of dividing-engines by an inspection of a dividing-engine constructed by Professor W. A. Rogers, at Waltham, in this State. On returning to Baltimore, I devoted much time to the general problem of such machines; and, through the liberality of the trustees of the Johns Hopkins University, I was enabled to construct an engine. In about a year this engine was finished. It worked perfectly the moment it was put together, and it has not been touched since. In order to rule diffraction-gratings, I reflected that it was necessary that the screw should be perfect, and that the rests for the plate which receives the ruling should also be as perfectly adjusted as is necessary in optical experiments.

The process of making the screw consisted in grinding it in a long nut in which it was constantly reversed. When this screw was finished, there was not an error of half a wave-length, although the screw was nine inches long.

When the dividing-engine was completed, my mind was occupied with the problem of the best form of surface to receive the ruling. I speedily discovered, that, by ruling the lines on a concave mirror of long focus, I could dispense with a collimator and with the ordinary arrangement of lenses. I now rule gratings six inches long, with various numbers of lines to the inch. I find that there is no especial advantage in having more than fourteen thousand to the inch, with the ordinary conditions of ruling. Having made the concave grating, I invented a simple arrangement for mounting it, so that a photographic

camera should move along the arc of a circle at one end of a diameter, upon the other end of which the grating was placed, and always remain in focus. With this apparatus, one can do in an hour what formerly took days. Moreover, the spectra obtained are always normal spectra, and every inch on a photograph represents a certain number of wave-lengths.

After finishing my apparatus, I found it necessary to study photography; and I therefore devoted much time to this subject, and made a special study of all known emulsions. I discovered that an emulsion containing eocene enabled me to photograph from the violet down to the D line; and other emulsions were used for the red rays. I have also been engaged in enlarging my negatives, and in printing from these negatives. On these enlarged photographs, lines are doubled which have always been supposed to be single. The E line is easily doubled. My map of wave-lengths is based upon Professor Charles S. Peirce's measurements of the wave-length of a line in the green portion of the spectrum.

The following paper was presented by title: —

"Deducing from one Epoch to another Stars very near the Pole." By William A. Rogers.

Seven hundred and seventieth Meeting.

March 12, 1884. — STATED MEETING.

The PRESIDENT in the chair.

The President announced the death of Johann F. J. Schmidt, of Athens, Foreign Honorary Member; and of George Engelmann, of St. Louis, Associate Fellow.

The Corresponding Secretary read an invitation from the Royal Society of Canada to attend its third annual meeting, at Ottawa.

Professor Pickering spoke of the importance of a representation before the legislature in regard to a new topographical map of the State. The chair appointed the following committee to consider this subject: —

Messrs. Edward C. Pickering, Asa Gray, and Samuel H. Scudder.

Professor Gray spoke upon the question of a rebatement of the fees of the Academy, and the following gentlemen were appointed a committee to consider this subject: —

Messrs. Edward Atkinson, Henry P. Kidder, and Thomas T. Bouvé.

On the motion of the Corresponding Secretary, it was

Voted, That the next meeting be an adjourned stated meeting.

The following papers were presented: —

"On the Systematic Observation of Variable Stars." By Edward C. Pickering.

"On a New Magnetic Theory of Molecular Action." By Harold Whiting. (By invitation.)

Seven hundred and seventy-first Meeting.

April 9, 1884. — ADJOURNED STATED MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters announcing the death of Signor Quintino Sella, of Turin, President of the Reale Accademia dei Lincei, of Rome; and of Dr. George Engelmann, of St. Louis.

The following papers were presented: —

"On the Determination of the Varying Positions of Circumpolar Stars." By William A. Rogers.

"On the Phases of the Moon." By Arthur Searle.

"On the Mean Right Ascensions of One Hundred and Thirty-three Stars near the North Pole." By Truman H. Safford.

The following papers were presented by title: —

"On β-Bromtetrachlorpropionic Acid." By Charles F. Mabery.

"On a- and β-Chlordibromacrylic Acids." By Charles F. Mabery and Rachel Lloyd.

"On β-dibromdichlorpropionic and β-bromdichloracrylic Acids." By Charles F. Mabery and H. H. Nicholson.

"On Orthoiodtoluolsulphonic Acid." By Charles F. Mabery and George H. Palmer.

Seven hundred and seventy-second Meeting.

May 14, 1884. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters announcing the death of François Auguste Alexis Mignet, Foreign Honorary Member; also, an invitation to the twenty-fifth anniversary of the Offenbacher Verein für Naturkunde.

The Corresponding Secretary also announced that Volume XIX. of the Proceedings would be ready for distribution at the adjourned annual meeting, and that the twentieth volume had been already begun.

The President announced the death of Charles Adolphe Wurtz, Foreign Honorary Member.

The following papers were presented: —

"Systematic Errors of Magnitudes in Star Catalogues." By Edward C. Pickering.

"Recent Photographic Investigations at the Massachusetts Institute of Technology." By William H. Pickering.

The following papers were presented by title: —

"Transverse Magnetic Effects in Various Metals." By Edwin H. Hall.

"A Comparison of the Right Ascensions derived from Harvard College Observations of Maskelyne Stars during the years 1870–79 with the Fundamental Systems of Newcomb and Auwers." By William A. Rogers.

"Results of Recent Investigations conducted at the Physical Laboratory, Cambridge." By John Trowbridge.